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TECHNOLOGY TRANSITION - ISSUES AND ANSWERS

DEFENSE SYSTEMS MANAGEMENT SCHOOL,
FORT BELVOIR, VIRGINIA

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PROGRAM MANAGEMENT COURSE
INDIVIDUAL STUDY PROGRAM

TECHNOLOGY TRANSITION--
ISSUES AND ANSWERS

STUDY PROJECT REPORT
PMC 76-1

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FORT BELVOIR, VIRGINIA 22060

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DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE: TECHNOLOGY TRANSITION--ISSUES AND ANSWERS

STUDY PROJECT GOALS:

To determine the points of controversy within the Air Force development and acquisition community concerning the use or consideration for use of laboratory developed technology.

STUDY REPORT ABSTRACT:

This report presents the results of an opinion survey concerning technology transition. Interviews of 11 Air Force executives were analyzed for points of agreement and disagreement. Three major controversies were identified and recommendations put forth for their resolution. The controversies are:

(1) Differences in expectations concerning both the allocating of technology resources and the nature of the technology product;

(2) Divided opinion on how much testing and design-to-cost is appropriate for technology;

(3) Divided opinion on the program office's limitations for incorporating technology products.

Implementation of the recommendations will increase the efficiency of the technology development and transition process.

KEY WORDS

MATERIEL DESIGN AND DEVELOPMENT WEAPON SYSTEMS RESEARCH LABORATORIES

TECHNOLOGICAL FORECASTS PROJECT MANAGEMENT

NAME, RANK, SERVICE	CLASS	DATE
JAMES W. WALTERS, LTC, USAF	PMC 76-1	MAY 1976

TECHNOLOGY TRANSITION--
ISSUES AND ANSWERS

Study Project Report

Individual Study Program

Defense Systems Management School

Program Management Course

PMC 76-1

by

James W. Walters
LTC USAF

May 1976

Study Project Advisor
Mr. William H. Cullin

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EXECUTIVE SUMMARY

For the purpose of this paper, technology transition is defined as:

> The consideration or evaluation for use on weapon systems, or the actual use on weapon systems of laboratory-developed applied science, manufacturing techniques, or other weapon knowledge.

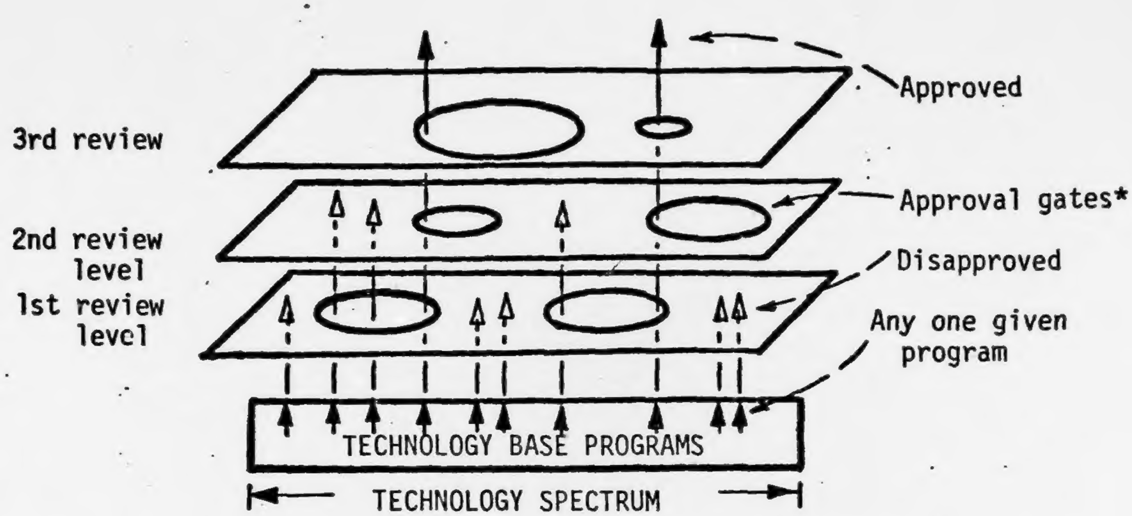
The process of technology development and its transition into weapon systems has taken place in a relatively unstructured environment during the recent past. This lack of structure was condoned because of the comparatively larger R&D budgets. Many technology developments proceeded without clear weapon system-related objectives. There was, consequently, a high program mortality rate - technology results were not applicable, therefore not used. Increasing the technology base in a shrinking budget period necessitates imposing a formal structure on the development and transition process so that available resources may be massed on those tasks judged most worthy. This requires corporate Air Force agreement and prioritization. (See Figure)

Based on an opinion survey of 11 US Air Force executives in weapons acquisition, this paper has identified key points of disagreement and proposes some recommendations for improving the technology transition process. Three major points of controversy identified via the opinion survey and suggested resolution processes are:

Controversy 1. There are differences in expectations of Air Force executives within the research and development community concerning both the decision process for allocating technology support and the nature of the technology product.

EXECUTIVE SUMMARY FIGURE

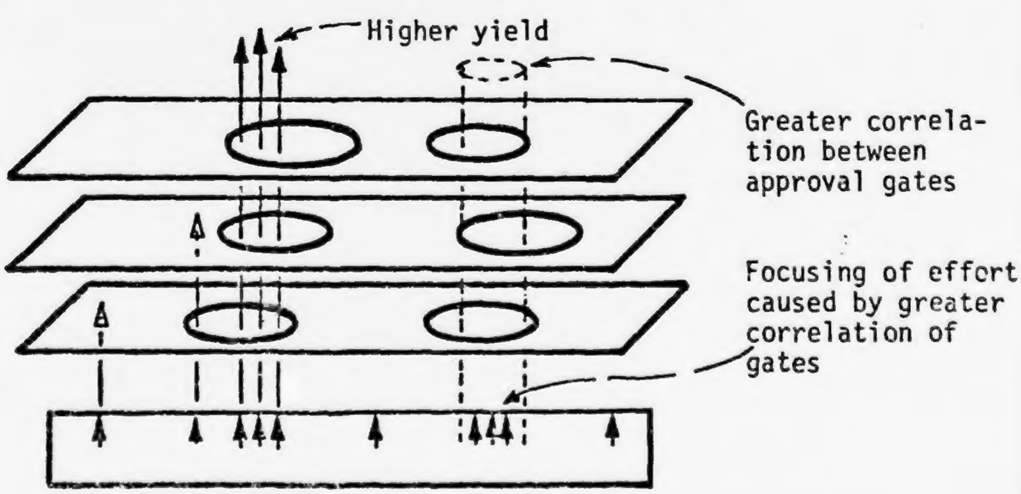
"SHOT-GUN" APPROACH



* • Approval Gates at the different command levels often represent different criteria/views for prioritizing technical base programs.

• Assuming a constant level of funding, an increase in yield from the technical base will require greater agreement between approval gates and a clearer understanding of those agreements at the program formuation level. This situation is shown in the following improved approach.

IMPROVED APPROACH



Resolution: Charter an action agency which would develop "top-down" Air Force policy and guidance representing executive judgment on the proper emphasis of the following six factors.

(1) opportunity gate emphasis.
(2) acquisition life cycle phase emphasis.
(3) technology product emphasis.
(4) level of integration complexity emphasis.
(5) time emphasis.
(6) guidance mechanism.

The agency should include representation from the technology developer, the headquarters (advocates and budget programmers) and the aggregate user (product divisions and operational commands). This guidance should be tailored to each technology area and updated annually.

Controversy 2. Opinion is divided into two strongly held positions concerning the degree of confidence needed in both the technology product's performance characteristics and its projected unit-production-cost (design-to-cost).

Resolution: An office of primary responsibility should be named to:

(1) Serve as a catalyst for formulating a compromise or a position which would be directed concerning the amount of testing/verification required of technology data or hardware.

(2) Establish development cost and/or projected unit-production cost thresholds for applying scaled design-to-cost or balanced design efforts on a technology program.

Controversy 3. Opinion is divided into two strongly held positions on the flexibility of the development process for incorporating technology products.

Resolution: One is not suggested.

Implementing these recommendations will foster a US Air Force team approach to technology development, and will increase the yield of the technology base.

ACKNOWLEDGEMENTS

The author is indebted to a large number of individuals who were most responsive and courteous to my inquiries. Specifically, special appreciation is expressed to:

- Major General Fred Ascani, USAF (Ret), and Major Donald Fujii, USAF, for their help in structuring the interviews;
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- Dr. David Charvonia, ODDR&E; Brigadier General Gerald Hendricks, AFSC/DL; Brigadier General James Marshall, ASD/EN; Colonel James Krause, AFAL/CD; and Colonel Robert Ziernicki, RDPV, for providing astute advice and additional material from their files;
- Lieutenant General James Stewart, ASD/CC, for arranging other appropriate contacts at Aeronautical Svstems Division;
- Mr. William Cullin, my Study Project Advisor; Mrs. Sandy Harris, typist; and my wife, editor, for their patience in the struggle to give birth to this paper.

Table of Contents

SECTION I

INTRODUCTION

Because the quality of future weapons systems is determined by the quality of the US technology base, the efficiency of technology development and utilization is of major importance.[1] This effort is based on an opinion survey taken on the subject. This survey was limited by time and funds to considering only technology transition as it relates to Air Force aircraft, with a bias to Avionics. However, the basic issues can be related across Service and across technology boundaries.

For the personal interviews, 11 executives at various levels in the Air Force weapons acquisition community were chosen as the representative sample of this population. (1-11)[2] Twelve questions, listed in Appendix A, were designed against a 45-minute appointment and proved to be very successful in drawing out individual viewpoints.

These interviews were supplemented with information from recent literature/briefings, some of which is so "fresh" that it has not yet been published.

[1]See Appendix B, Background (Appendix C, Appendix D)

[2]This notation, [Number(s):Number(s)], will be used throughout the report for sources of quotations and major references. The first number set is the source(s) listed in the bibliography. The second number set is the page(s) in the reference. Notations without page number listing indicate interview sources in the bibliography.

The survey is based on opinions held in two key areas:

(1) What type of technology is desired and needed for transitioning?

(2) What is the best, most effective transition mechanism?

For the purpose of this paper, technology transition is defined as:

The consideration or evaluation for use on weapon systems, or the actual use on weapon systems of laboratory-developed applied science, manufacturing techniques, or other weapon knowledge.

The types of technology are:

(1) Data: Reports, analyses, ideas, design to specifications, build to specifications, consultation, tests, etc.

(2) Hardware: Components, lab concept demonstration breadboards, flight feasibility demonstration brass boards, mil-spec-qualified hardware, etc.

Transition mechanisms are:

(1) Direct: Government developer to government user.

(2) Indirect: Government develops within industry--industry transitions to government user.

The study determined that major issues in terms of discontinuities, polarization of opinions, and expectation differences exist. In objectively communicating these issues, the study proposes to aid the development community in directing problem-solving energies.

Polarized opinions are identified by a bimodal distribution; the discontinuities are identified by the opinion statistical mean (focused opinion) differing from the "real-world" situation; the expectation differences (widely varying opinions) are identified by a wide deviation. (37:17-40)

SECTION II

SEARCH FOR AND ANALYSIS OF THE ISSUES

Type of Technology Issues

Two major controversies identified by this paper were found to be associated with the first six interview questions and related to the first of the two key areas; i.e., type of technology. Table II-1, formed from these six questions, clearly depicts an overview of the opinion alignment. The "No Response" blocks indicate the questions were not addressed for lack of time.

Note that the only tendency to agree related to question 4, "Should laboratory programs be conducted in-house or through contracts?" All respondents agree that the labs should be in-house oriented; the variance is concerned with the degree of in-house orientation.[1] Regardless of the individual's position on how much in-house is enough, there were two general areas of agreement:

(1) Work only in areas of military interest, and

(2) Do not work in areas where technology is driven by non-DOD forces.

The variance between "some" and "all" in-house is concerned with the reason for doing the work; i.e., is it for:

(1) Engineering training and motivation?

(2) Technology base planning and coordination?

(3) Simulation/emulation (problem anticipation)?

(4) Hardware testing?

---

[1]The interviews were conducted with a non-attribution policy, and no reference will be identified with an interview opinion.

TABLE II-1

TYPE OF TECHNOLOGY

Question — **Responses**

Question	All Levels (Components, Sensors, Sub-systems)	Limited	Very Limited (Components only)	No Response
1. Labs should work at what integration complexity level?	3	4	3	1

Question	Full Mil Spec	Limited	Very Limited	No Response
2. Design qualified at what level?	3	6	1	1

Question	More D-T-C	Some D-T-C	None	No Response
3. Dollars for Design-to-Cost versus more technology options?	1	5	4	1

Question	Most In-House	Limited In-House	Very Limited	No Response
4. In-house versus contract?	5	4	0	2

5. How prioritize technology programs?

No Priorities: 2

Prioritize by:	Response
·Top down--System Needs for Missions	1
·Synchronize with Future Force Structure	1
·Product Improve Today's System Developments	1
·Opportunity Gates for Threats/Applications/Voids	1
·Functional Categories Considering Threat and Industry	1
·Military Interest/Needed Expertise/Far-out Ideas with High Return on Investment	1
·Near-term JSOP Emphasis	1
·Near-term Return on Investment	1
·Corporate Body Wisdom	1

Question	Conceptual	Development	In Service	No Response
6. Prioritize support for different weapon system life phases.	3	2	2	4

The apparent opinion agreement does not correlate in all cases, however, to the "real-world" situation. These responses, when compared to actual situations, especially Avionics technologies, indicate some current disagreement--thus a discontinuity exists. For example, in the higher integration complexity tasks (components integrated into sensors; sensors integrated into mission function subsystems), there is a definite lack of in-house, hands-on hardware capability. One reason for this lack is that the higher the integration task complexity, the more costly the in-house facilities.

The other five questions are discussed within the previously identified issue categories of expectation differences and polarized opinions.

Expectation Differences

Question 1: At what level of technology integration complexity should the Air Force technologist be working?

Question 5: Should technology efforts be prioritized? If so, by what system? If not, how allocate decreasing dollars?

Question 6: How would you prioritize laboratory thrusts between (1) developing new concepts, (2) supporting systems in development, and (3) improving inventory systems?

This particular set of questions surfaces one of the three major issue areas identified by the survey. Its resulting frustrations are particularly noticed within the technology community (What to do? What to do first?), and companion frustrations are observed in the systems community (Labs need to solve real-world problems; labs are not interested in my problems). In the commercial market, this problem is

reduced because the customer is clearly identified--he has the money. (The user does not often have the money in the weapons acquisition situation.) The DOD Laboratory Utilization Study proposes solving the problem in this manner:

> Recognizing that the primary responsibilities for most materiel acquisition work rests with designated Program Managers, the laboratories should operate their materiel acquisition work on an industrially funded basis in a customer/supplier relationship with the appropriate Program Managers.[1] The degree of their involvement would ultimately be governed by the customers' satisfaction with their contribution to his program. (13:30)

This represents a significant "strawman" for consideration and debate. Some expressed opinions conflict with this proposed solution in two noteworthy areas.

1. Is the Program Manager (PM) the "real" customer?

Or is he being employed by higher headquarters and the operations commands to manage the building of a device because of his special skills and contacts? Is he not the agent representing the "near-term" needs of an aggregate customer? With the PM's "power of the purse" (last sentence of the above quote) and his narrowed interest, the laboratories would become directed to near-term problem-solving. The DOD study proposed alleviating the ". . . laboratories being completely subjugated to the Program Managers . . ." (13:30)[1] by requiring a technical assessment annex (TAA) to accompany all decision coordination papers (DCPs).

[1]Underlining added.

Originally, the lab-prepared TAA was intended to be independent of the SPO, but recent indications are that the SPO would be responsible for preparing it in concert with a lead laboratory. (30:1) Notice in Table II-1 that only two responses to question #5 clearly advocated a near-term emphasis on technical developments.

Finally, "what type technology" is a question not likely to be answered because, at any point in time, the programs capable of industrially funding a lab would represent a spectrum of near-term interests--interests varying from conceptual option support through product improvement support; from wanting components through wanting major subsystems; from needing data to needing hardware. This leads into the second area of opinion conflict: timeliness.

2. Will today's PM provide adequate guidance for developing the technical base for the next generation of systems?

It would appear at the least very difficult, if not a practical impossibility, for a PM who typically must concentrate on this year's and next year's problems to give effective guidance for the "creation of options" to solve tactical, strategic, etc., problems which are beyond his tenure. Even if this were conceded, equally serious is the doubt that a program manager's orientation is the preferred orientation from which to provide this guidance. Considering that it takes the commercial industry 20 to 25 years to transition a technology, the military goal of 7 to 10 years[1] makes the scheduling of lead time and

[1]Based on an interview reference.

the identification of the appropriate office-of-primary responsibility (OPR) central concerns.

From the above discussion, one of the three major needs for successfully transitioning technology is "top down" policy and guidance which represents executive judgment on the proper emphasis for the following six-dimensional matrix:

(1) opportunity gate emphasis (Should technology programs be aligned primarily to: force structures, missions, threats, functions, technology areas?)

(2) acquisition life cycle phase emphasis (In what priority should technology programs support: concept, validation, full-scale development, production, deployment or disposal?)

(3) technology product emphasis (Should technology programs primarily produce data or hardware?)

(4) level of integration complexity emphasis (In what priority or to what degree should technology programs produce: materials, components, devices, minor subsystems, sensors, major subsystems?)

(5) time emphasis (What time frame should technologists primarily support: 1-2 years; 3-6 years; or 7-12 years from today?)

(6) guidance mechanism (OPR for formulating the previous 5 emphases should be: program managers, planning staffs, operational commands, standing committees).

In concluding the discussion on this set of expectation differences, one respondent's observation that "AFSC's investment strategy concept is a good first step" is most appropriate. This concept considers several

of the dimensions but not all. In addition, the first AFSC implementation represented a higher headquarters assessment of "bottoms up" proposals. This "bottoms up" method has an inherent time lag between creation of technology proposals and a higher level review of their appropriateness. Therefore, it will tend to cause untimely programs, and it tends to create an attitude of "can't do anything right" at the worker level. A more efficient, responsive approach which is also more motivating is that of providing the technology developers with the basic "top-down" guidance listed above.

The opinions in this area do not seem to be overly rigid and could likely be brought into much closer agreement by the use of more "top-down" guidance which communicates needs, available resources, and corporate policy. An action agency should be designated/commissioned for the purpose of developing that policy as it relates to each technology area. The agency should include representation from the technology developer; the headquarters (advocates and budget programmers); and the aggregate user (product divisions and operational commands). This agency should update and revise the guidance on an annual basis.

Polarized Opinions

Question 2: At what level should data/hardware be verified/qualified?

Question 3: Should technology funds be spent on design-to-cost (D-T-C) design iterations or on providing more technology options?

This set of questions surfaces the second major issue area--polarized opinions concerning the type of technology needed.

Question #2 is concerned with determining the level of technical performance confidence desired in new technology. This question revealed sharp differences and relatively strong opinions which fell into three divisions:

- High confidence data/Full Mil-Spec qualified hardware
  - -- Get more for dollar by testing early.
  - -- Know wear spots and need do only necessary testing.
  - -- Do lots of testing in order to convince PMs of equipment's low risk to their program.
- Feasibility/Functional performance demonstration
  - -- Provide more data than hardware.
  - -- Brassboard evaluated by experienced engineers and assessed as an acceptable risk.
  - -- Show that it will work, it is air worthy, and it can be integrated.
- No qualification testing
  - -- Combined environmental testing and reliability improvement warranties should be enough for future equipment.

Since these are executive-level viewpoints, it would be very difficult to smooth over, to get a unanimous view, or to get an effective majority decision. Therefore, compromise or legislation appears to be the proper approach for this conflict resolution. An OPR should be named to serve as a catalyst for compromise and for recommending a position for legislation.

Question #3 was directed to determining the corporate confidence desired in a development for achieving a given unit-production-cost. The opinions, which were not so strongly expressed as those of question #2, fell into two well-defined groups.

- No D-T-C
  - -- D-T-C is a mistake in labs. Should work on options which intrinsically have lower cost.
  - -- Must have some cost consciousness, but D-T-C is a mistake.
- Some D-T-C
  - -- Must have cost sensitivity in technical options; i.e., cost no greater than . . . .
  - -- Balanced design process which injects discipline is good. Some funds should be allocated for this purpose.
  - -- Should be looking at lessons learned, maintenance approaches, common parts, which reduce life cycle costs instead of pushing performance.

This issue could be decided by higher headquarters' establishing development cost and/or projected unit-production cost thresholds for applying an appropriately scaled D-T-C or balanced design effort.

TRANSITION MECHANISM ISSUES

In the second of the key areas, transition mechanism, there was basic agreement on how technology should be used to form new weapon systems. Only one area of major conflict appeared, and it seems to be growing due to recent shifts in opinions. Table II-2 is formed from the responses to Questions 7 through 11, and is an overview of this area.

First, the Agreements:

Question 7: What is the best technology transition mechanism?

The responses were overwhelmingly in favor of the indirect method (through industry) as the most effective/practical. A distinction is made in this case between "best" and "effective." "Best" is regarded as

TABLE II-2

TRANSITION MECHANISM

Question	Through Lab	Combination	Industry	No Response
7. Best technology transition mechanism?	0	5	5	1

Question	Yes	Sometimes	No	No Response
8. Is government expertise and lab credibility an issue?	0	2	4	5

Question	Yes	Possibly	No	No Response
9. Better approach to developing US technology base than labs?	0	0	7	4

10. See a way of effectively disseminating government-sponsored industry knowledge?

--Maybe not best to.
--Real problem is peril of concentrated sponsorship.
--Competition is a strong barrier.

Question	Yes	Maybe	No	No Response
11. Are program managers too constrained to adequately consider new technology?	2	1	3	5

transitioning the most cost-effective combination of technologies for "just good enough" accomplishment of a mission function. Often, licensing fees, maintaining a competitive edge, decisions on sharing of team profits, etc., cause less than the "best" technology combinations to be structured as a system design. Therefore, "effective" is regarded as the utilization of the technology base in a responsive, innovative, adequate fashion. The middle-of-the-road position is as follows:

- -- Labs work with industry to develop technical options.
- -- PMs work with labs in selecting and tailoring the appropriate technology for their system.
- -- PMs go directly to industry because of industry's responsiveness and innovation. (Program offices need a company's commitment for performance, integration, reliability and production delivery.)

Some regarded the direct method (from labs to SPOs) as the "best" method, but many practical drawbacks existed relating to adequacy of testing, production status, and schedule risks.

Question 9: Is there a better approach to developing the US technical base than the government laboratory approach?

The response was unanimously "no". Several supportive comments were:

- -- Lab programs are strong signals for focusing Independent Research and Development (IR&D).
- -- Labs can look across the industrial base.
- -- Contractors are not too interested in service maintenance realities.
- -- Labs provide planning and coordination of the technical base as it relates to the military need.

In addition, the DOD Laboratory Utilization Survey addressed this issue in depth and also stated the same position for the same basic reasons. (13:27)

Question 10: Do you see a way of effectively disseminating government-sponsored contractor knowledge?

The basic opinion is "no" for the three reasons shown in Table II-2. One very knowledgeable source said:

> Competition is a <u>strong</u> barrier: Licensing fees and profit potential is as large a consideration as performance. Design concepts are constrained by these liaisons as much as by desired performance.

<u>Selective/Scattered Discontinuity</u>

Question 8: Are government engineering competence and lab credibility issues?

A potential controversy which is not identified as a major issue is the apparent difference between agreement that there is no issue and the actual situation.

Some instances can be cited when program offices choose to use industry for analysis, simulations or testing as opposed to commissioning laboratories. A statement like the previous sentence almost immediately begins an argument betwen program office and laboratory people. The purpose here is not to join the debate, but to identify an area where opinion may not be in line with given situations.

The <u>third major controversy</u> identified by the study concerns the issue category of "polarized opinion" and evolves from:

Question 11: Is the program manager's charter too limiting to allow adequate consideration of new technology?

The polarization is rather sharp on the "no" side and represents strong support for PM prime responsibility. The basic feeling is that there is nothing in a PM's charter to prevent his considering and using any level of technology.

From the other viewpoint, events of the recent past have stimulated debate on the advisability of causing a program to "drive toward seemingly inflexible goals"--particularly schedule goals.

Some comments supporting "yes" responses:

-- Maybe the "silo effect"[1] makes it difficult to cross-fertilize between SPOs.

-- Relax some of the inflexible goals and use more front-end financing for testing and change.

-- Loosen up schedules to allow consideration of attractive options as they mature.

Very candidly, I am not comfortable enough with this issue to propose an answer or an approach to an answer. It will only be identified.

---

[1]The "silo effect" is the strong vertical structuring of a particular program.

SECTION III

CONCLUSION

Discussion

The process of technology development and its transition into weapon systems has functioned in a relatively unstructured environment. Because of comparatively larger R&D budgets during the recent past, many technology developments were permitted to proceed without clear weapon system related objectives--a shot gun[1] approach. Consequently, a high mortality rate-or non-use of technology results occurred. (Fig 1a)

In a period where real R&D budgets are shrinking, the high mortality "shot gun" approach, with its lack of return-on-investment, is a prime area for review. In order to increase the efficiency of the technology transition process, it will be necessary to impose some formal structure on the system to cause available resources to be massed on selected target technologies. This will increase the technology base yield by excluding unneeded Air Force developments. Effecting this procedure will require corporate Air Force agreement and prioritization. (Fig 1b)

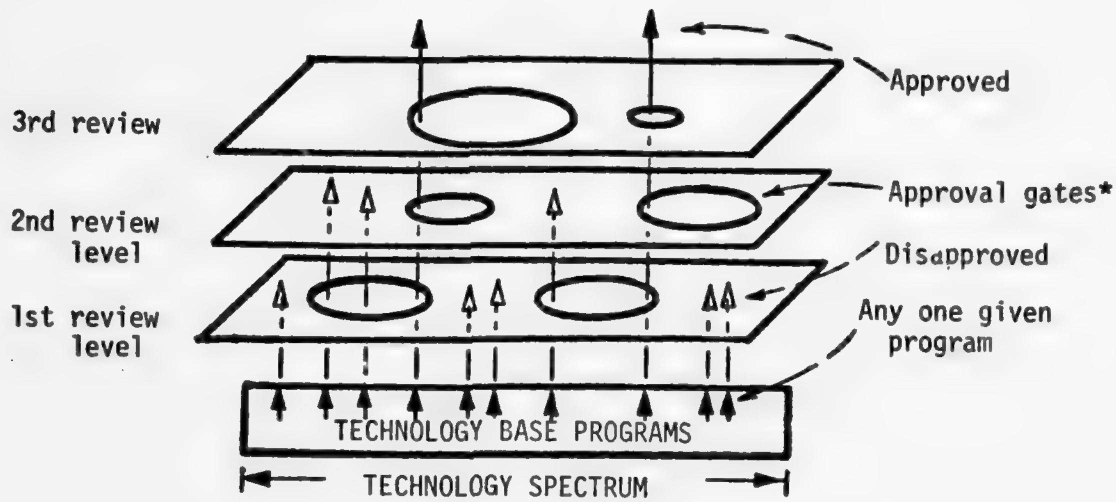
To that end, this paper has identified the major points of controversy concerned with technology transition and has proposed some structuring of the (1) decision process for program formulation and prioritization, and (2) application of testing and design-to-cost requirements. The summary of these findings and recommendations follows.

---

[1]See money put into many, many program which had, at their inception, no apparent opportunity for inclusion in a needed or useful weapon system. The idea was to put a great deal of knowledge on the shelf "in case it might be needed." Faith is placed in the "good ideas" forcing their way out of the morass of developments.

FIGURE III-I

"SHOT-GUN" APPROACH



* • Approval Gates at the different command levels often represent different criteria/views for prioritizing technical base programs.

• Assuming a constant level of funding, an increase in yield from the technical base will require greater agreement between approval gates and a clearer understanding of those agreements at the program formuation level. This situation is shown in the following improved approach.

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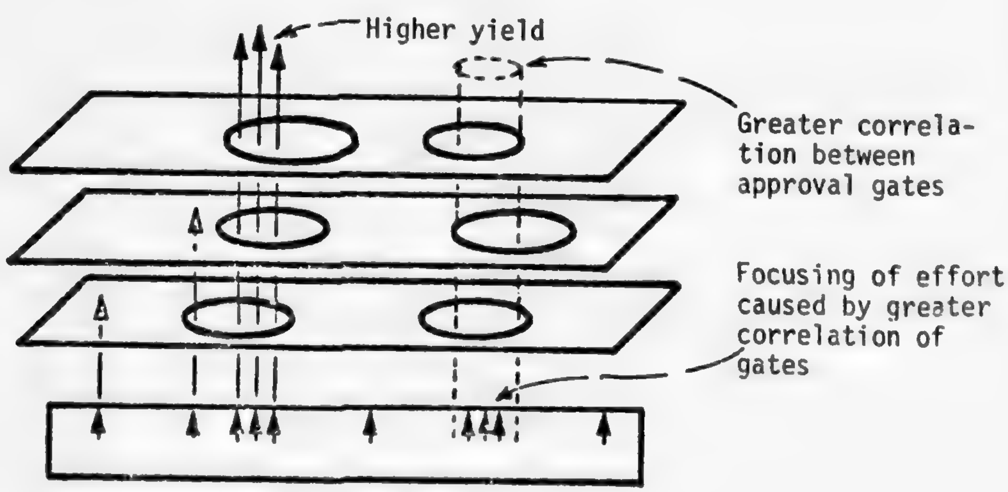


Summary

Table III-1 summarizes the identification of opinion disagreement by type/category of issue and by its association with either (1) the planning and developing of the technical base, or (2) the mechanism for utilizing that base for molding a total weapon system.

TABLE III-1

FINDING SUMMARY

ISSUE CATEGORY	KEY AREAS: Type Technology	KEY AREAS: Transition Mechanism
Expectation Differences	• Integration Complexity Task Level • Prioritization Criteria	
Polarized Opinion	• Qualification Testing • How Much D-T-C	• PMs Limited in Considering new Technology
Discontinuities	• In-house vs. Contract*	• Government Expertise Credibility*

*Scattered discontinuities

There were no discontinuities identified as major controversies. The two shown in the table (in-house vs. contract, government expertise credibility) are not of a general nature; it can only be claimed that the disagreement between the focus of opinion and the actual condition exists in scattered/specific situations.

Therefore, three major controversies exist and they are identified, along with the recommended resolution approach:

Controversy 1. There are differences in expectations of Air Force executives within the research and development community concerning both the decision process for allocating technology support and the nature of the technology product.

Resolution: Charter an action agency to develop "top-down" policy and guidance which represents executive judgment for the proper emphasis of the following six factors. This emphasis should be tailored to each technology area.

(1) opportunity gate emphasis (Should technology programs be aligned primarily to: force structures, missions, threats, functions, technology areas?)

(2) acquisition life cycle phase emphasis (In what priority should technology programs support: concept, validation, full-scale development, production, deployment or disposal?)

(3) technology product emphasis (Should technology programs primarily produce data or hardware?)

(4) level of integration complexity emphasis (In what priority or to what degree should technology programs produce: materials, components, devices, minor subsystems, sensor, major subsystems?)

(5) time emphasis (What time frame should technologists primarily support: 1-2 years; 3-6 years; 7-12 years from today?)

(6) guidance mechanism (OPS for formulating the previous 5 emphases should be: program managers, planning staffs, operational commands, standing committees.)

the agency should include representation from the technology developer, the headquarters (advocates and budget programmers) and the aggregate user (product divisions and operational commands). The guidance should be updated annually.

Controversy 2. Opinion is divided into two strongly held positions concerning the degree of confidence needed in both the technology product's performance characteristics and its projected unit-production-cost (design-to-cost).

Resolution: An office of primary responsibility should be named to:

(1) Serve as a catalyst for formulating a compromise or a position which would be directed concerning the amount of testing/verification required of technology data or hardware.

(2) Establish development cost and/or projected unit-production cost thresholds for applying scaled design-to-cost or balanced design efforts on a technology program.

Controversy 3. There is polarized opinion on the flexibility of the development process for incorporating technology products.

Resolution: One is not suggested.

Implementing these recommendations will foster a US Air Force team approach to technology development, and will increase the yield of the technology base.

Further study effort in this area could (1) expand the sample population to missiles, ground equipment and weapons; or (2) expand the sample to a multi-service orientation.

APPENDIX A

INTERVIEW QUESTIONS

1. At what level of technology intergration complexity should the Air Force technologists be working?

2. At what level should data/hardware be verified/qualified?

3. Should technology funds be spent to design-to-cost (D-T-C) design iterations or on providing more technology options?

4. Should laboratory programs be conducted in-house or through contractors?

5. Should technology efforts be prioritized? If so, by what system? If not, how should decreasing dollars be allocated?

6. How would you prioritize laboratory thrusts between (1) developing new concepts, (2) supporting systems in development, and (3) improving inventory systems?

7. What is the best technology transition mechanism?

8. Are government engineering competence and lab credibility issues?

9. Is there a better approach to developing the US technical base than the government laboratory approach?

10. Do you see a way of effectively disseminating government-sponsored contractor knowledge?

11. Is the program manager's charter too limiting to allow adequate consideration of new technology?

12. Any other comment?

APPENDIX B

OVERVIEW/NEED OF THE TECHNOLOGY BASE

Considering the given definition for technology, the following series of excerpts are used to establish the need for effective technology transition. Note first the size of the technology option budget as given by the:

DOD Laboratory Utilization Study.

> Research (6.1), Exploratory (6.2), and Advanced Development (6.3) resources constitute over 35% of DOD's RDT&E FY 77 budget--$3.88 billion out of $10.94 billion.[1] FY 75 DOD Laboratory personnel strength--56,741. (Appendix D)

A next logical question is, "With this level of resource input, what is the US position compared to the USSR?" The following is a synopsis of a limited, but important, evaluation stated by:

Dr. Malcolm R. Currie--DDR&E Statement to the 94th Congress.

> Of 21 key technology areas (includes titanium fabrication, welding, high-pressure physics, high-energy lasers, anti-ship missiles, high-frequency radio-wave propagation, and application of advanced plasma physics), the USSR clearly leads in 8 areas and has gained parity or shares a mixed lead in 3 other areas. (Appendix C)

The question of why better technology is needed is spoken to by the Secretary of the Air Force:

Air Force Authorization Request

> As we face the specter of rapidly advancing technological challenge from our potential adversaries, a continuing commitment to R&D programs oriented toward essential technological advance will provide the basis for a strong Air Force in the years ahead. (35:8)

Obviously, technology needs more money to achieve this advancement. It appears that Congress is going to agree to additional monies in FY 77, but the problem is not so easily solved. Dr. Allen and Brigadier General Gerald Hendricks have made these observations on (1) technology applicability, and (2) technology transitioning to weapon systems.

DOD Laboratory Utilization Study.

> DDR&E characterized US Air Force laboratories as specializing in technology base problems, thereby isolating them from Air Force problems. (13:xii)

AFSC Director of Science and Technology

> Technology Transfer and Payoff
> What is the Problem?
> ·Convincing people that a new idea, technique, specification, or design is understood, reliable, and workable. (14:Slide 8)

Finally, consider the experience of a development which illustrates the situation:

The Air Force Avionics Laboratory High Reliability Radio Story

> --Two competitive contractors developed their prototype model UHF radio and demonstrated 1185 and 785 hours MTBF, respectively.
> --The F-15 SPO refused a free supply of enough units for their first set of test aircraft, and purchased APR-109's (less MTFB/more expensive).
> --Why? The APR-109 was in production; had more testing; was backed by a contractor; had a lower delivery schedule risk.

It would be easy to lapse into a fault-finding mode, but there are situations and conditions on both sides of the development "fence" which cause this type of unfortunate story, and one purpose of this paper is to examine objectively these conditions and identify the central issues for management attention.

The following four basic points are derived from the excerpts and depict the overview/need for technology base transition:

(1) Technology base resources are a very large portion of the total allocated development resources.

(2) The US has a marginal technology base advantage over the USSR.

(3) Ultimate military systems superiority is derived from a superior technical base.

(4) There exist situations and conditions which are limiting the effective molding of the US technical base into the best possible weapon systems.

The excerpts are representative of a large number of sources which make the same four points, and represent the current development community motivation to identify and eliminate the inhibitors of effective technology transition.

TECHNOLOGY	STATUS
High-pressure physics	USSR leads; major investment in equipment, investment in programs of intrinsic scientific interest and speculative military applications.
Integrated-circuit fabrication	U.S. leads.
Welding	USSR leads, with an extensive basic research program leading to many innovations.
Computers	U.S. leads, especially in civil, commercial fields.
Titanium fabrication	USSR has a strong lead.
High-yield nuclear weapons	Parity--USSR has made several unique developments.
High bypass-ratio turbofans	U.S. leads.
High frequency radio-wave propagation	USSR appears to have a strong lead in several application areas.
Air-to-Air missiles	U.S. has a strong lead; no foreseeable USSR counterpart to some systems.
Numerically controlled machine tools	U.S. leads; USSR designs around needs.
Avionics	U.S. has a strong lead in radars for surveillance, bombing, and air-to-air combat.
Magneto-hydrodynamic power generation	USSR leads.
Composite materials	U.S. leads; Soviets are making a strong effort to catch up.
Aerodynamics	Mixed; U.S. leads in use of computers for design and simulation, but Soviets have developed unusual low-altitude configurations.

TECHNOLOGY	STATUS
Inertial instrumentation	U.S. leads; technology is maturing and any significant lead is diminishing.
Anti-ship missiles	USSR leads in deployed systems.
Chemical warfare	USSR lead is stable.
Precision guided weapons	U.S. leads.
Satellite-borne sensor technology	U.S. has strong and increasing lead in areas where comparisons are possible.
High-energy lasers	Uncertain; USSR has large program involving approaches not being pursued by the U.S.
Artillery technology	USSR leads in many areas.

RDT&E PROGRAM BY BUDGET CATEGORY

($ MILLIONS)

CATEGORY	FY 1975	FY 1976	FY 19TQ	FY 1977	FY 1978
Research	300.6	329.7	82.8	383.4	441.9
Exploratory Dev	1,083.8	1,184.4	302.4	1,342.4	1,506.0
Advanced Dev	1,704.6	1,930.3	542.6	2,155.7	2,842.8
Engineering Dev	2,938.2	3,531.4	827.0	4,241.2	4.202.4
Mgt & Support	1,186.6	1,256.9	334.0	1,386.4	1,422.7
Oper Sys Dev	1,422.0	1,295.4	308.4	1,433.2	1,486.9
TOTAL RDT&E	8,635.8	9,528.1	2,397.2	10,942.3	11,902.7

RDT&E BY TYPE OF PERFORMER

($ MILLIONS)

PERFORMER	FY 1975	FY 1976	FY 19TQ	FY 1977	FY 1978
Industry	5,810.1	6,546.8	1,630.6	7,846.9	8,712.4
Government In-House	2,436.6	2,580.5	667.6	2,661.4	2,723.6
Federal Contract Research Centers (FCRC)	192.9	202.4	50.3	221.7	233.6
Universities	196.2	198.4	48.7	212.3	233.1
TOTAL RDT&E	8,635.8	9,528.1	2,397.2	10,942.3	11,902.7

RDT&E PROGRAM BY MISSION AREA

($ MILLIONS)

MISSION AREA	FY 1975	FY 1976	FY 19TQ	FY 1977	FY 1978
Tactical	2,985.9	3,361.4	831.6	4,227.7	4,720.9
Strategic	2,135.3	2,341.9	582.1	2,406.3	2,360.3
Defensewide Sys	659.0	710.7	169.6	765.9	917.1
Technology Base	1,397.9	1,537.8	393.7	1,765.7	1,998.9
Management & Spt	1,202.7	1,276.4	339.1	1,416.1	1,460.9
Adv Tech Dev	255.0	299.9	81.1	360.6	444.6
TOTAL RDT&E	8,635.8	9,528.1	2,397.2	10,942.3	11,902.7

RDT&E PROGRAM BY COMPONENT

($ MILLIONS)

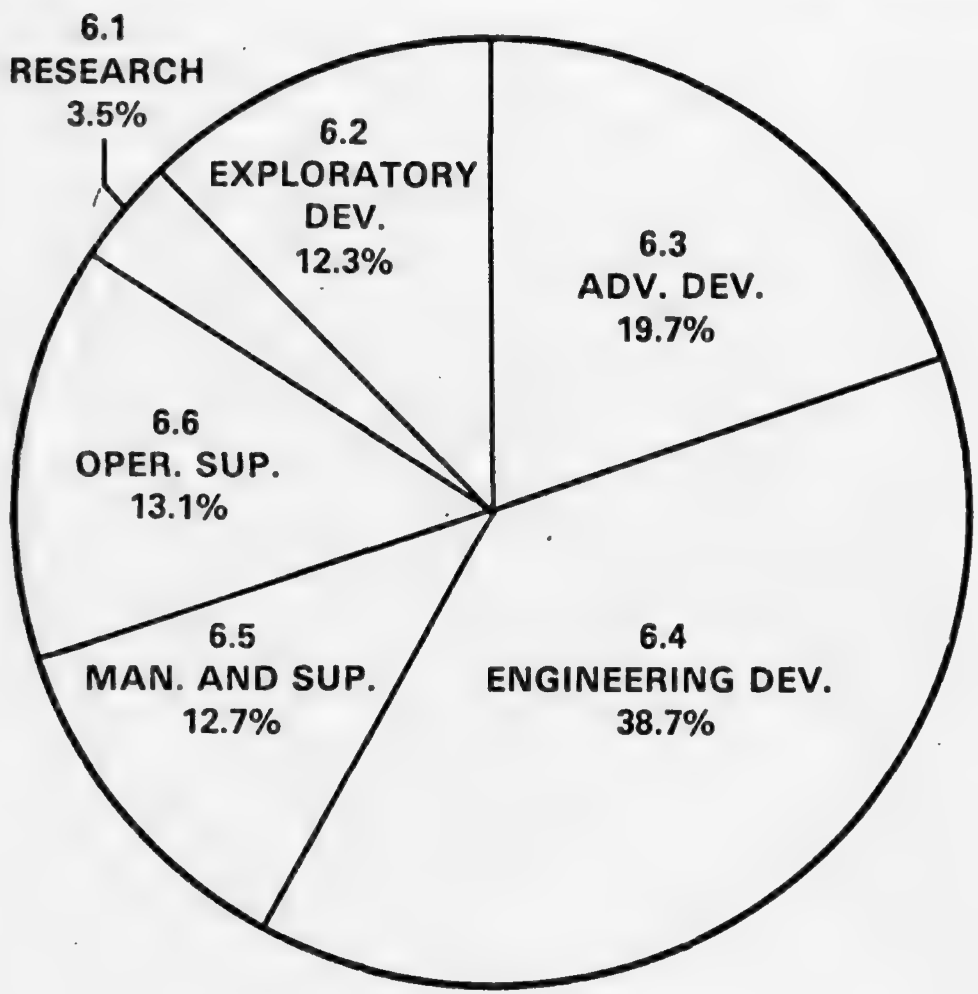
DEPARTMENT	FY 1975	FY 1976	FY 19TQ	FY 1977	FY 1978
Army	1,769.6	1,974.9	512.7	2,386.2	2,572.7
Navy	3,051.6	3,317.2	826.1	3,925.2	4,325.7
Air Force	3,298.9	3,606.6	906.9	3,924.6	4,208.2
Defense Agencies	515.7	629.4	151.5	706.3	796.1
TOTAL RDT&E	8,635.8	9,528.1	2,397.2	10,942.3	11,902.7

RDT&E PROGRAM BY BUDGET ACTIVITY

($ MILLIONS)

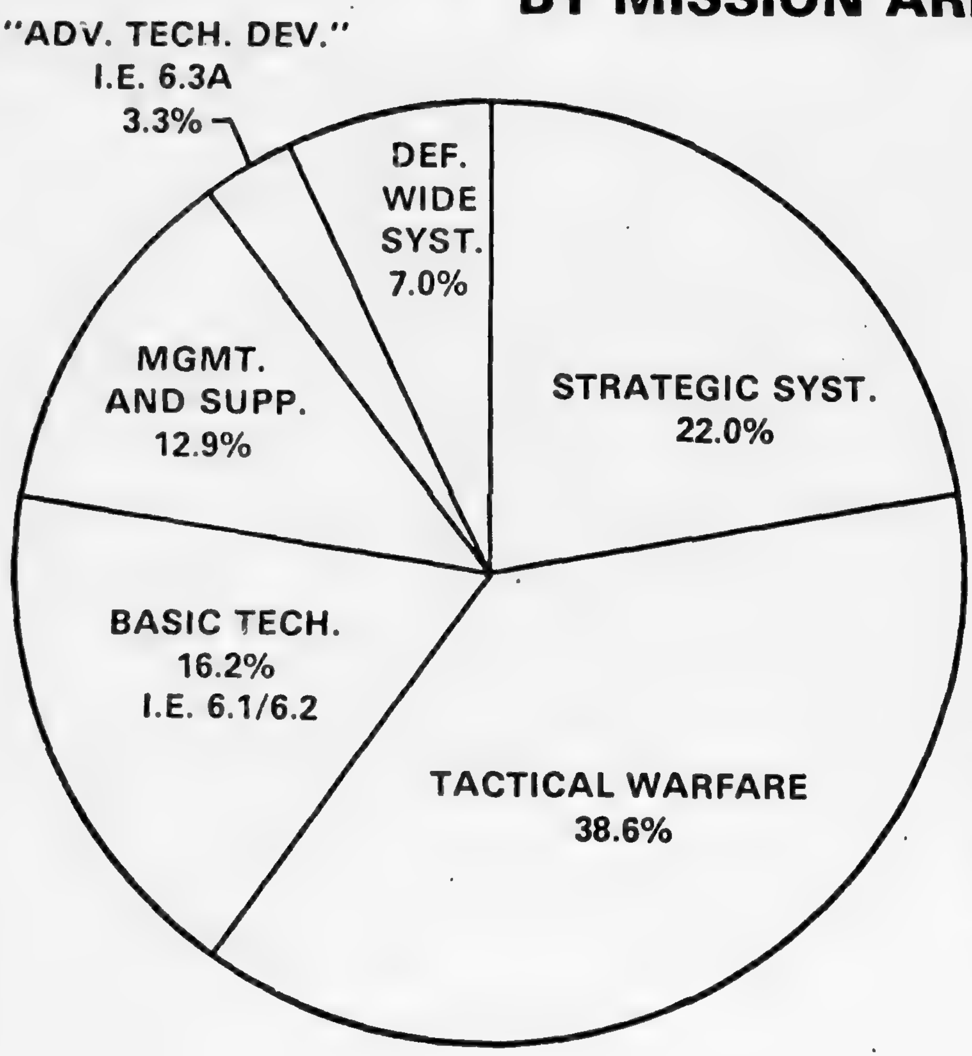
BUDGET ACTIVITY	FY 1975	FY 1976	FY 197T	FY 1977	FY 1978
Military Sciences	411.9	448.9	114.3	524.0	594.6
Acft & Rel Equip	1,626.9	1,940.1	447.7	2,273.4	2,480.5
Msle & Rel Equip	2,107.0	2,279.4	569.0	2,552.9	2,604.1
Astronautics	527.7	583.6	134.1	599.7	769.3
Ships & Sm Craft	666.2	595.4	162.6	750.8	824.4
Ord Cmbt Veh Rel Eq	471.1	556.2	166.8	753.0	792.9
Other Equipment	1,857.2	2,098.9	527.6	2,352.4	2,668.5
Mgt & Support	967.8	1,025.6	275.1	1,136.1	1,168.4
TOTAL RDT&E	8,635.8	9,528.1	2,397.2	10,942.3	11,902.7

RDT&E FY 77 BUDGET
BY TYPE OF WORK



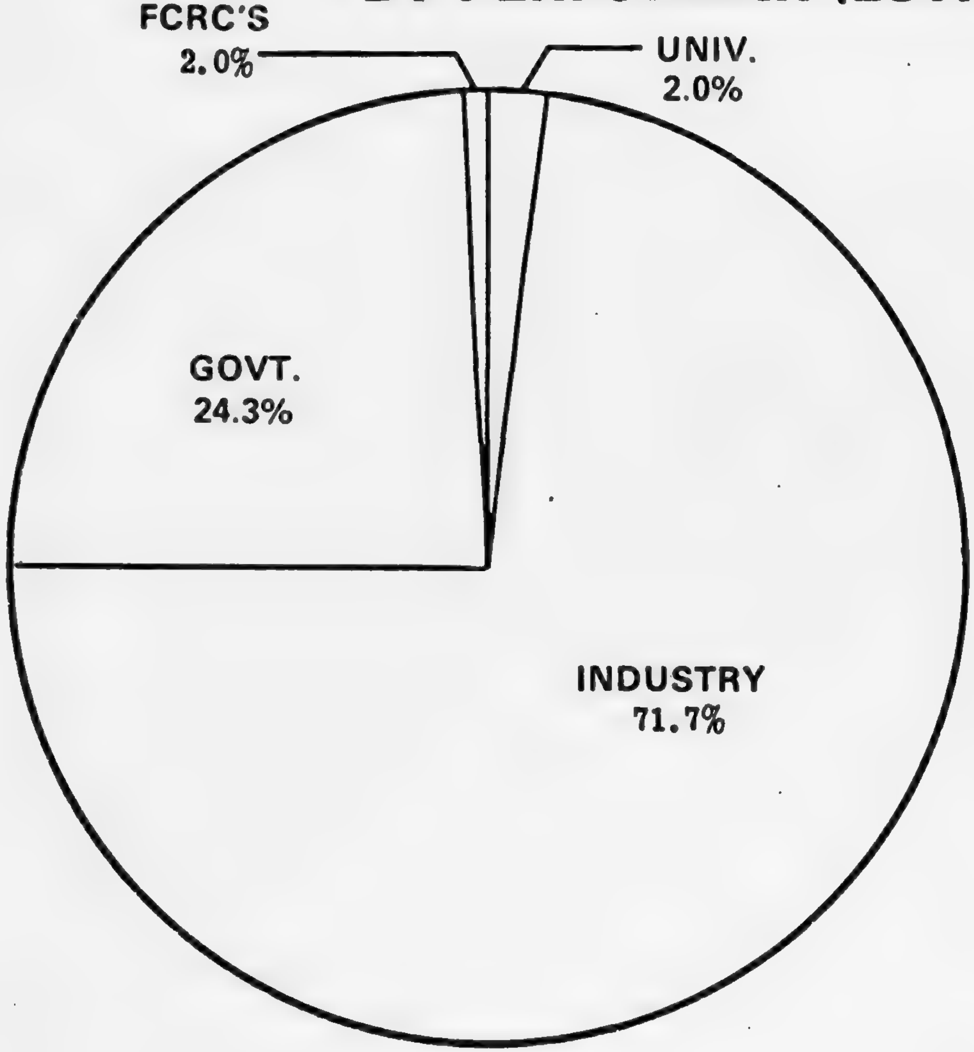
	(MILLIONS)
RESEARCH	383.4
EXPLORATORY DEV.	1,342.4
ADVANCED DEV.	2,155.7
ENGINEERING DEV.	4,241.2
MANAGEMENT AND SUPPORT	1,386.4
OPERATIONAL SYS. DEV.	1,433.2
TOTAL	10,942.3

RDT&E FY 77 BUDGET
BY MISSION AREA



	(MILLIONS)
TACTICAL WARFARE	$4,227.7
STRATEGIC SYSTEMS	2,406.3
DEFENSE-WIDE SYSTEMS	765.9
BASIC TECHNOLOGY	1,765.7
MANAGEMENT AND SUPPORT	1,416.1
ADV. TECH. DEV.	360.6
TOTAL	10,942.3

RDT&E FY 77 BUDGET
BY PERFORMER (ESTIMATED)



	(MILLIONS)
INDUSTRY	7,846.9
GOVT. IN-HOUSE	2,661.4
FEDERAL CONTRACT RESEARCH CENTERS (FCRC'S)	221.7
UNIVERSITIES	212.3
TOTAL	10,942.3

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